Biosecurity protocols for the prevention of spread of porcine reproductive and respiratory syndrome virus

Andrea Pitkin, BS MS
Satoshi Otake, DVM PhD
Scott Dee, DVM MS PhD Dip ACVM

Swine Disease Eradication Center
University of Minnesota College of Veterinary Medicine

Acknowledgements

American Association of Swine Veterinarians Foundation
Minnesota Rapid Agricultural Response Fund

Swine Disease Eradication Center Partners

Pig Improvement Company
Genetiporc
Boehringer-Ingelheim
Pharmacological Solutions, Inc.
Pfizer Animal Health
Novartis Animal Health
Noveko
Pipestone Veterinary Clinic
Fairmont Veterinary Clinic
Clinique Demeter
Swine Vet Center

Table of Contents

Introduction

Porcine reproductive and respiratory syndrome (PRRS) is an economically significant disease of swine that has been estimated to cost the US industry approximately $560 million a year. Preventing the spread of PRRSV within and between pig populations is a critical component of a farm's disease control program. To aid in controlling the spread of this agent, this manual provides a summary of data from experiments conducted from our group at the University of Minnesota that were specifically designed to identify the routes of PRRSV transmission and to develop protocols of biosecurity to reduce this risk. All protocols have been, and continue to be validated during an on-going experiment that has been in process over the past 2 years at our Swine Disease Eradication Center (SDEC) production region model farm. The authors of this manual continue to practice these protocols and procedures on a daily basis; therefore, as of this writing our confidence in their ability to prevent PRRSV spread is very high. We hope that swine veterinarians can utilize this information to help their clients develop effective biosecurity programs for sustainable PRRS control.

Virus Overview

Prior to discussing how the virus spreads between farms and within populations of pigs, it is important to understand its host range and biochemical characteristics. Based on the excellent work of several investigators, we know that the etiologic agent of PRRS, porcine reproductive and respiratory syndrome virus (PRRSV), is a single-stranded positive sense RNA virus classified in the order *Nidovirales*, family *Arteriviridae* and genus Arterivirus. PRRSV has also been shown to be a host-specific virus, capable of infecting only pigs. Therefore, no other mammalian, insect or avian species can serve as biological vectors of the virus. In regards to its capability for survival outside of the pig, PRRSV is susceptible to high temperatures, changes in pH (< 6 and > 7.65), and prolonged exposure to UV light as well as chemical inactivation. While PRRSV can survive for months to years when frozen (-20 degrees C), as temperature increases, its survivability decreases. For example, the virus can survive for 6 days at 21 degrees C, for 24 hours at 37 degrees C and for only 20 minutes at 56 degrees C. In addition, when kept moist, the virus is viable out to 11 days.

Routes of Spread and Protocols of Biosecurity

Direct routes (live animals and semen)

As stated, pigs are the only animal capable of becoming infected with PRRSV. Once infection occurs, the virus can be shed from persistently infected pigs via blood, saliva, milk and colostrum, urine and feces, as well as contaminated semen. Therefore, purchasing genetic material from naïve sources that are monitored on a regular basis is critical. Vet-to-vet communication to review the current health of the herd prior to purchase is recommended, followed by quarantine and testing of animals. The following are examples of protocols to reduce the risk of PRRSV entry to farms via the introduction of genetic material:

- Isolation
  - An isolation (quarantine) facility is a critical component of a PRRSV biosecurity program. Isolation facilities should be located greater than 120 meters from the breeding herd and ideally, off-site. Incoming stock should be kept separate from resident stock for a minimum of 30 days. Animals should be monitored daily for clinical signs by farm personnel. The herd veterinarian should remain in close communication with the seedstock supplier's veterinarian during this period in case the onset of a disease is suspected in the source population or the animals in quarantine.

- Testing
  - Replacement stock should be blood tested 24-48 hours after arrival to the isolation facility as well as 5-7 days prior to their entry to the breeding herd. Once infected, PRRSV RNA can be detected in the bloodstream 24 hours post-infection; therefore, testing of samples by PCR is recommended to enhance detection of peracute infections. Samples collected late in the isolation period can also be tested by ELISA for the presence of PRRSV antibodies.

  - With the advent of the blood swab technique, AI centers can proactively monitor their status via PCR testing of blood from boars being collected that day, along with the regular testing of semen, again by PCR. With the ability of diagnostic labs to provide "one day turnaround" of PCR results, producers and veterinarians can receive semen validated as PRRSV-negative in real-time and safely introduce it to their herds.

Blood testing isowean gilts in quarantine

Indirect routes

PRRSV can be mechanically transmitted in a number of ways. The following section will review routes of transmission and outline the biosecurity protocols designed to help prevent spread via these routes.

Facilities

Swine facilities should be managed using all-in, all-out (AIAO) pig flow, thereby reducing the spread of PRRSV from older, infected pigs to younger, naïve animals. In conjunction with AIAO flow, it is important to properly sanitize the facilities before introducing susceptible animals. Examples of the steps required to sanitize facilities that housed PRRSV-positive animals are as follows:

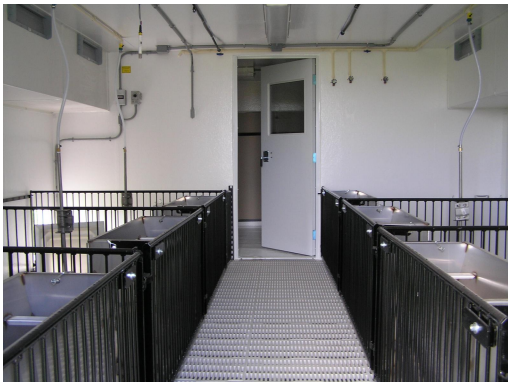
- All organic material (feces, urine, feed, bedding and body fluids) should be completely removed and the surfaces power washed. Special attention should be paid to the gating, feeders, waterers, slats in the floors and any other "cracks or crevices" where such material could be harbored and missed.

Removal of debris is critical for proper sanitation of facilities

- Once clean, an efficacious disinfectant should be applied throughout the pen area. Some examples of products proven to be efficacious against PRRSV are quaternary ammonium+ glutaraldehyde mixtures (Synergize) and modified potassium monopersulfate (Virkon). These products should be applied at a 0.8% and 1% concentration, respectively for a minimum of 2 hours. The application of disinfectants via a foamer allows for better visualization of where product has been applied and also prolongs the contact between the chemicals and the surfaces.

Application of disinfectants via a foamer enhances their effectiveness

- Following cleaning, the facility must be allowed adequate downtime or drying time after disinfection. This is the most important step in the sanitation protocol for complete inactivation of the virus.



A properly sanitized nursery room

Needles

Once a pig is infected, the quantity of PRRSV in the blood stream typically reaches high levels. Therefore, injection of consecutive animals using a contaminated needle can result in hematogenous spread of the virus. To reduce this risk, it is recommended to change needles between sows during third trimester injections or utilize "needle-free" technology.

Transport vehicles

PRRSV can be spread to susceptible animals following contact with contaminated transport vehicles. Therefore, as with facilities, stringent compliance with cleaning/ disinfection and drying protocols is critical for sanitizing the trailers of transport vehicles. Potential risk points in the cab of the truck (pedals, floor mats, etc) can be effectively sanitized using disinfectant spray, such as Lysol. In regards to trailers:

- All organic material (feces, urine, feed, bedding, etc) should be removed. Special attention should be paid to "hard to reach" sites, such as corners of trailers, gate hinges/latches, etc where this material could be harbored.

Contaminated transport can serve as a source of PRRSV infection of naïve pigs

- Once clean, efficacious disinfectants should be applied to the vehicle using previously described concentrations, periods of contact and method of application.

Drying is the most important component of a transport sanitation program

- Following sanitation, the vehicle must be allowed adequate drying time after disinfection. As with facilities, this is the most important step in the sanitation protocol to completely inactivate the virus. The use of high-volume warm air can decrease the amount of time needed for drying. The thermo-assisted drying and decontamination (TADD) system developed by PIC is recommended to achieve a dry trailer in the shortest amount of time. Studies have indicated that 120 minutes of high volume warm air applied via the TADD method can effectively remove PRRSV from contaminated surfaces in transport trailers.

Personnel

The hands, coveralls and boots of personnel can serve as mechanical vehicles for PRRSV. Below are protocols to reduce the risk of PRRSV spread via these routes:

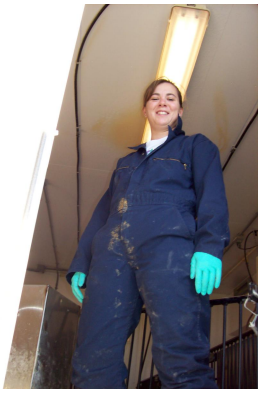
Entry protocols

- Downtime
  - Personnel should practice one night of downtime before entering a farm. Research has shown that extended periods of downtime are not necessary for this agent.
- Shower in-shower out
  - Shower protocols have been proven to successfully decontaminate personnel contaminated with PRRSV prior to entry. The use of such a procedure upon entry to the system each day is recommended.

- Danish entry system
  - This system utilizes the changing of coveralls and boots plus the washing of hands in designated areas prior to entering the animal air space and has been demonstrated to be very effective for reducing the risk of PRRSV spread by personnel between sites and buildings.

Hands

- Gloves
  - The use of gloves can help prevent transfer of virus. Gloves should be changed regularly, i.e. between litters.
- Sanitizers and hand washing
  - Frequent hand washing and use of sanitizers that contain iodine can successfully remove virus from hands.



Coveralls

- Coveralls
  - Barn-specific coveralls should be available in all facilities and washed routinely. Disposable coveralls are also an option.

Boots

- Footbaths
  - Use of footbaths can greatly help reduce the risk of PRRSV transfer between groups of pigs. Baths should be changed at least every day to maintain disinfectant efficacy. Chlorine bleach, quaternary ammonium + glutaraldehyde mixtures (Synergize) and modified potassium monopersulfate (Virkon) disinfectants are effective.

- Disposable or facility-specific boots should be used. Boots should never leave the farm and should be power-washed to remove feces from the soles and disinfected routinely.

Fomites

Contaminated fomites, such as farm supplies and containers can serve as mechanical vehicles for PRRSV. Therefore, all incoming supplies should be disinfected and allowed a minimum of 2 hours contact time prior to introduction. "Double bagging" supplies is an acceptable method for reducing the risk of spread. A specific room should be used as a disinfection and drying room for fomites (D&D room). All incoming supplies should be placed in this room, disinfected on all sides and allowed the minimum 2 hour contact time prior to entry. This can be done using a cold fog mister to create a "fog" of disinfectant. After 5 minutes minimum contact time, the fomites should be rotated, "fogged" on their downside for a minimum of 5 minutes and then allowed to remain in the room for a minimum of 2 hours. Quaternary ammonium + glutaraldehyde mixtures (Synergize) and modified potassium monopersulfate (Virkon) disinfectants diluted to 0.8% and 1% respectively are recommended for use in this situation.

Aerosolizing disinfectants in a designated D&D room can be useful when sanitizing incoming supplies

Insects

House flies and mosquitoes can serve as mechanical vectors of PRRSV and can transport the virus at least 2.4 km from an infected farm. The site of retention of the virus in the fly is the GI tract and the rate of viral decay over time is influenced by quantity ingested and environmental temperature. In order to prevent spread of PRRSV via insects the following steps are recommended:

- Screens
  - All inlets, windows and areas that could be accessed by insects should be covered with screens. In order to maintain proper ventilation, screens must be cleaned regularly.

The use of insect screen on side wall inlets has been demonstrated to significantly reduce insect entry.

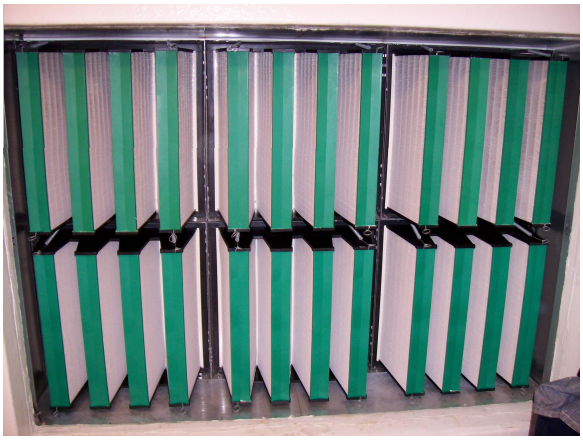
- Insecticides
  - Pyrethrin-based insecticides are highly effective and are commercially available as premises sprays or washes.
- Insect bait
  - The use of insect bait, i.e. Quik-Strike strips, is an effective means to control the number of insects.
- Site management
  - Cutting the grass and removing weeds surrounding swine facilities as well as removal of standing water are also recommended for eliminating insect breeding areas.

Aerosols

- Airborne spread of PRRSV appears to be isolate-specific. As new highly pathogenic isolates of PRRSV have emerged, such as MN-184 and 1-18-2, their ability to travel long distances via aerosols appears to have increased in contrast to earlier isolates. Recent research has demonstrated the ability of infectious PRRSV to be transmitted by aerosols over a distance of 120 meters. However, preliminary results from experimental studies along with field reports indicate that aerosol transmission of PRRSV can occur at least up to 3.3 km (2 miles) or more (Dee et al, manuscript in preparation). Therefore, as isolates adapt, so must the biosecurity protocols if there is any chance of providing sustainable disease control.

- To reduce the risk of airborne spread of PRRSV, the adaptation of filtration systems to swine facilities has come about. These early systems have utilized MERV 16 (95% DOP @ $\geq$ 0.3 microns) filters and results over the last 2-3 years have been encouraging. Installation of an air filtration system depends upon the individual producer's budget, the location of the site (high swine density vs. low density), the level of acceptable risk and type of production system, i.e. seedstock or commercial. Filters can be installed one of two ways, either in the attic through insertion of filters into the ceiling inlets or in the form of a filter bank preceding the cool cell pad.

A single MERV 16 filter

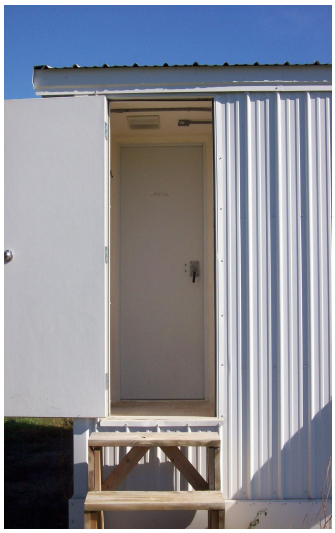


A bank of 6 MERV 16 filters

If an air filtration system is installed in a building which is ventilated using negative pressure, all areas of the barn that could serve as potential air leaks need to be sealed. This includes cracks in the building and around windows and doors, shutters and idle fans. In addition, "double door" entry/exit systems must be installed to prevent potentially contaminated air from entering the animal air space at high risk points, such

as personnel entryways, live/dead animal load out rooms, D&D rooms, etc. The protocol of the double door system involves the use of a chamber and specific procedures:

- The chamber must contain an external door and an internal door which communicates with the animal air space. When entering from the outside, the external door is opened, personnel or pigs enter a chamber and the door is closed. The same process occurs when entering the chamber from the inside of the building via the internal door.

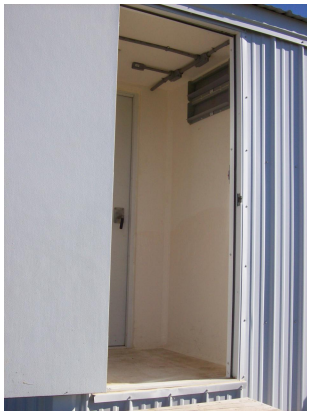


An external view of the double door chamber

- The chamber must also contain an exhaust fan designed to clear all the air in the room in a certain time frame, i.e. 1-5 minutes, depending on room volume. To aid in evacuating contaminated air, "clean" air is drawn into the chamber via a baffle inlet from an ante-room or an animal air space within the facility. Once animals/personnel have entered and both doors are closed, the fan is turned on and allowed to run for the designated time period.

A view of the exhaust fan within the chamber

- Once the evacuation period is over, the interior door can be opened allowing personnel/pigs to enter inside the facility or leave the facility via the external door.



A view of the baffle inlet in the chamber

Note: The double-door system has been extensively tested and found to be highly efficacious at preventing the introduction of virus via contaminated aerosols, both at the SDEC production region model and on filtered commercial farms. It is important to work with an experienced engineer to determine the proper fan size and evacuation period according to the volume of each chamber on the farm.

Miscellaneous

Other facts regarding PRRSV transmission which may be important for producers to consider when developing their farm-specific biosecurity protocols are as follows:

Pig meat

Meat from infected pigs can harbor PRRSV for at least 7 days at 4 degrees C and for months when frozen at -20 degrees C. Therefore, fresh or frozen pig meat should not be allowed into a swine facility at any time.

Lagoon effluent

PRRSV can survive in lagoon effluent for up to 3 days at 20 degrees C and for 7 days at 4 degrees C. Contact with PRRSV-positive effluent can serve as a source of infection to naïve pigs. Therefore, producers that utilize recycled lagoon water in their waste management protocols may be at higher risk for external virus introduction than those who use deep pits.

Carcass disposal

PRRSV can be inactivated through the process of composting or incinerating carcasses. Therefore, only these methods should be applied. Allowing rendering trucks to drive onto farm premises should be avoided at all times.

Incineration is an effective means of disposing of PRRSV-positive carcasses

Concluding remarks

Based on our experience over the past 2 years, under well controlled field conditions the protocols summarized in this document are highly effective at preventing PRRSV spread between populations of pigs. Obviously, personnel compliance is the key to successful implementation of such procedures. Veterinarians can play an important role, not only as the team member who delivers science-based biosecurity to the farm but also as a teacher to educate personnel and an auditor to insure compliance is maximized. By practicing the above protocols, it is hoped that producers can effectively reduce the risk of PRRSV introduction to their herds and maintain a high standard of swine health and production on their farms. In addition, broad application of a comprehensive PRRSV biosecurity program across farms may aid in reduction of viral spread within a region, enhancing the success of area-based control and eradication programs.

Suggested reading

The information on PRRSV transmission and biosecurity summarized above is based on data derived from the following peer-reviewed studies published by our group:

Airborne spread

Pitkin AN, Deen J and Dee SA. Use of a production region model to assess the airborne spread of porcine reproductive and respiratory syndrome virus. *Vet Microbiol* (In press).

Cho JG, Dee SA, Deen J, Guedes A, Trincado C, Fano E, Jiang Y, Faaberg K, Collins JE, Murtaugh MP and Joo HS. The influence of animal age, bacterial co-infection and porcine reproductive and respiratory syndrome virus (PRRSV) isolate pathogenicity on virus concentration in individual pigs. *Am J Vet Res* 2006;67:489-493

Cho JG, Dee SA, Deen J, Trincado C, Fano E, Murtugh MP, Collins JE and Joo HS. An evaluation of different variables on the shedding of porcine reproductive and respiratory syndrome virus in aerosols. *Can J Vet Res* 2006;70:297-301.

Cho JG, Dee SA, Deen J, Murtaugh MP, and Joo HS. An evaluation of isolate pathogenicity on the transmission of porcine reproductive and respiratory syndrome virus by aerosols. *Can J Vet Res* 2007;71:23-27.

Dee SA, Deen J, Cano JP, Batista L, and Pijoan C. Further evaluation of alternative air filtration systems for reducing the transmission of porcine reproductive and respiratory syndrome virus by aerosols. *Can J Vet Res* 2006;70:168-175.

Dee SA, Deen J, Batista L, and Pijoan C. An evaluation of alternative systems for reducing the transmission of porcine reproductive and respiratory syndrome virus by aerosols. *Can J Vet Res* 2006;70:28-33.

Dee SA, Batista L, Deen J, and Pijoan C. An evaluation of an air filtration system for the prevention of porcine reproductive and respiratory syndrome virus transmission by aerosols *Can J Vet Res* 2005;69:293-298.

Fomites and personnel

Pitkin AN, Deen J and Dee SA. Further assessment of fomites and personnel as vehicles for the mechanical transport and transmission of porcine reproductive and respiratory syndrome virus. *Can J Vet Res* (Accepted for publication).

Dee SA, Deen J, Rossow KD, Eliason R, Mahlum C, Otake S, Joo HS, and Pijoan C. Mechanical transmission of porcine reproductive and respiratory syndrome virus throughout a coordinated sequence of events during warm weather. *Can J Vet Res* 2003. 67:12-16.

Dee SA, Deen J, Rossow KD, Mahlum C, Otake S, Joo HS and C Pijoan. Mechanical transmission of porcine reproductive and respiratory syndrome virus throughout a coordinated sequence of events during cold weather. *Can J Vet Res* 2002. 66: 232-239.

Dee SA, Deen J, and Pijoan C. An evaluation of four intervention strategies to prevent mechanical transmission of porcine reproductive and respiratory syndrome virus. *Can J Vet Res* 2004. 68:19-26.

Otake S, Dee SA, Rossow KD, Deen J, Joo HS, Molitor TW, and Pijoan C. Transmission of porcine reproductive and respiratory syndrome virus by fomites (boots and coveralls). *Swine Health Prod* 2002. 10(2): 59-65.

Otake S, Dee SA, Rossow KD, Deen J, Joo HS, Molitor TW, and Pijoan C. Transmission of PRRSV by needles. *Vet Rec* 2002. 150, 114-115.

Insects

Pitkin AN, Otake S, Deen J, Moon RD, Dee SA. Further assessment of houseflies (Musca domestica) as vectors for the mechanical transport and transmission of porcine reproductive and respiratory syndrome virus under field conditions. *Can J Vet Res* (Accepted for publication).

Schurrer JA, Dee SA, Moon RD, Deen J, and Pijoan C. An evaluation of 3 intervention strategies for the control of insects on a commercial swine farm *Swine Health Prod* 2006;14:76-81.

Schurrer JA, Dee SA, Moon RD, Murtaugh MP, Finnegan CP, Deen J , Kleiboecker SB, and Pijoan C. Retention of ingested porcine reproductive and respiratory syndrome virus in house flies. *Am J Vet Res* 2005;66:1517-1525.

Schurrer JA, Dee SA, Moon RD, Rossow KD, Mahlum C, Mondaca E, Otake S, Fano E, Collins JE, and Pijoan C. Spatial dispersal of porcine reproductive and respiratory syndrome virus-contaminated flies following contact with experimentally infected pigs *Am J Vet Res* 2004. 65:1284-1292.

Otake S, Dee SA, Moon RD, Rossow KD, Trincado C, and Pijoan C. Studies on the carriage and transmission of porcine reproductive and respiratory syndrome virus in an individual housefly (*Musca domestica,* Linnaeus). *Vet Rec* 2004. 154:80-85.

Otake S, Dee SA, Moon RD, Rossow KD, Trincado C and Pijoan C. Evaluation of mosquitoes (*Aedes vexans,* Meigen) as biological vectors of porcine reproductive and respiratory syndrome virus. *Can J Vet Res* 2003. 67:265-270.

Otake S, Dee SA, Moon RD, Rossow KD, Trincado C, Farnham M, and Pijoan C. Survival of porcine reproductive and respiratory syndrome virus in houseflies (*Musca domestica* Linnaeus*) Can J Vet Res* 2003. 67:198- 203.

Otake S, Dee SA, Rossow KD, Moon RD, Trincado C, and Pijoan C. Transmission of porcine reproductive and respiratory syndrome virus by houseflies, (*Musca domestica* Linnaeus). *Vet Rec* 2003. 152: 73-76.

Otake S, Dee SA, Rossow KD, Moon RD, and Pijoan C. Transmission of porcine reproductive and respiratory syndrome virus by mosquitoes (*Aedes vexans)*. *Can J Vet Res* 2002. 66:191-195.

Otake S, Dee SA, Jacobson L, Torremorell M, and Pijoan C. Evaluation of aerosol transmission of porcine reproductive and respiratory syndrome virus under field conditions. *Vet Rec* 2002 150, 804-808.

Transport

Dee SA, Torremorell M, Thompson R, Cano JP, Deen J, and Pijoan C. Evaluation of the thermo-assisted drying and decontamination system (TADD) for the sanitation of full-size transport vehicles contaminated with porcine reproductive and respiratory syndrome virus. *Swine Health Prod* 2007;15:12-18.

Dee SA, Deen J and Pijoan C. An evaluation of an industry-based sanitation protocol for full-size PRRSV-contaminated transport vehicles. *Swine Health Prod* 2006;14:307-311.

Dee SA, Deen J, and Pijoan C. An evaluation of an industry–based sanitation protocol for PRRSV-contaminated transport vehicles. *Swine Health Prod* 2006;14:126-132.

Dee SA, Deen J and Pijoan C. Evaluation of disinfectants for the sanitation of porcine reproductive and respiratory syndrome virus-contaminated transport vehicles at cold temperatures. *Can J Vet Res* 2005; 69:64-70.

Dee SA, Torremorell M, Deen J, Thompson B and Pijoan C. An evaluation of the Thermo-Assisted Drying and Decontamination (TADD) system for the elimination of porcine reproductive and respiratory syndrome virus from contaminated livestock transport vehicles. *Can J Vet Res* 2005; 68:208-214.

Dee SA, Deen J, Burns D, Douthit G and Pijoan C. An assessment of sanitation protocols for commercial transport vehicles contaminated with porcine reproductive and respiratory syndrome virus. *Can J Vet Res* 2004. 68:208-214

Dee SA, Deen J, Otake S, and Pijoan C. An assessment of transport vehicles as a source of porcine reproductive and respiratory syndrome virus transmission to susceptible pigs. *Can J Vet Res* 2004. 68:124-133.

Miscellaneous

Cano JP, Dee SA, Deen J, Finnegan C, Murtaugh MP and Pijoan C. An exploratory study to evaluate the survival of porcine reproductive and respiratory syndrome virus in non-processed pig meat. *Vet Rec* 2007, 160:907-908.

Dee SA, Martinez BC and Clanton CJ. Survival and infectivity of porcine reproductive and respiratory syndrome virus in swine lagoon effluent. *Vet Rec* 2005; 156,56-57.

Trincado C, Dee SA, Rossow KD, Halvorson D, and Pijoan C. Transmission of porcine reproductive and respiratory syndrome virus by non-porcine vectors: A re-evaluation of Mallard ducks. *Vet Rec* 2004. 154:233-237.

Batista L, Dee SA, Rossow KD, Polson DD, Xiao Z, Olin M, Molitor TW Murtaugh MP and Pijoan C. Detection of porcine reproductive and respiratory syndrome virus in pigs with low positive or negative ELISA s/p ratios. *Vet Rec* 2004.154:25-26.

Cho JG and Dee SA. Porcine reproductive and respiratory syndrome. *Theriogenology*, 2006;66:655-662.